



Review of the congrid eel genus *Conger* (Anguilliformes: Congridae) in Taiwan

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Abstract

The congrid eel genus *Conger* in Taiwan is reviewed. Five species are recognized, including *C. jordani*, *C. cinereus*, *C. macrocephalus*, *C. myriaster* and a newly collected species, *C. philippinus*. A mature male specimen of *Conger myriaster* is described for the first time. Specimens previously identified as *C. japonicus* (= *C. myriaster*) were misidentifications of above mentioned species. The diagnostic characters are discussed. Detailed data on all five species and a key to species in Taiwan are provided.

Key words: Pisces, Taxonomy, Congridae, biodiversity, Taiwan

Introduction

The congrid eel genus *Conger* is a group of moderate to large eels characterized by a well-developed flange on the lips of both jaws; maxillary and mandibular teeth in 1 or 2 rows, the outer row forming a cutting edge; the posterior nostril situated in front of mid-eye; vomerine teeth blunt and conical, forming a small patch, and a prominent adnasal pore.

Conger is one of the longest-known and most familiar of the eel genera. *Conger conger* was described by Linnaeus (1758) and has been an important food fish in European waters since ancient times. Its image can be found on Roman-era mosaics. *Conger myriaster* (Brevoort, 1856) has long been commercially important in Japan, but in spite of this it remains poorly known in terms of its taxonomy and life history.

The genus was revised by Kanazawa (1958), who recognized 14 species, one of which (*Conger cinereus*) he divided into two subspecies. Although his paper is extremely useful, it had the unfortunate side effect of inhibiting further work on the genus. With a “revision” already published, subsequent workers largely ignored *Conger* in favor of groups that were less well-known. Not a single new species has been described since 1958, and only three authors (Asano, 1962; Castle, 1964, 1968; Smith, 1989) did any original systematic work on *Conger*. Other references have been largely in the context of regional faunal lists.

Kanazawa’s study material was not well balanced geographically. He had many specimens from Japan and the North Atlantic, but aside from *Conger cinereus* he had only five specimens from the Philippines, four from Hawaii, and none at all from other island groups in the Pacific. In the intervening 60 years much additional material has been collected. Study of this material is likely to increase the known diversity of the genus.

The genus *Conger* currently comprises 14 nominal species, with nine species occurring in the Indo-Pacific Ocean and five in the Atlantic Ocean. In Taiwan, three species were commonly recorded, *Conger cinereus* Rüppell, 1871, *C. japonicus* Bleeker, 1879, and *C. myriaster* (Chen & Weng, 1967, Shen *et al.*, 1993, Ho *et al.*, 2010).

Smith *et al.* (2016) confirmed that *C. japonicus* Bleeker, 1879 is a junior synonym of *C. myriaster* and that four species are present in Japan: *C. myriaster*, *C. jordani* Kanazawa, 1958, *C. erebennus* (Jordan & Snyder, 1901), and *C. cinereus*. Examination of specimens identified as *C. japonicus* in Taiwan revealed that they were misidentifications of other species, most likely *Conger macrocephalus* Kanazawa, 1958 and *C. jordani*. Recently,

Ho *et al.* (2015) provided a checklist of eels of Taiwan and recognized four species, *C. jordani*, *C. myriaster*, *C. cinereus* and *C. macrocephalus*. In addition, two specimens of *Conger philippinus* Kanazawa, 1958 collected from southwestern Taiwan represent the first record of the species from Taiwan.

In this work, we provide detailed information on all these species and provide a key to all known species from Taiwan.

Methods and materials

Counts and measurements are as in Smith & Kanazawa (1977). Institutional abbreviations are as in Fricke & Eschmeyer (2018). Proportions are given as percentage of total length (TL), preanal length (PAL) and head length (HL). Other abbreviations are DFO (dorsal-fin origin), GO (gill opening), SO (supraorbital pores), IO (infraorbital pores), POM (preoperculo-mandibular pores), POP (preopercular pores), ST (supratemporal pores) and MVF (Mean vertebrae formula).

Because the posterior end of the tail of some specimens were broken, not all specimens were measured. An asterisk (*) before the registration number of specimen indicates specimens with data taken.

Conger differs from most other congrid genera in having a well-developed pore at the end of the adnasal canal, which extends a short distance dorsally from the anterior end of the infraorbital canal just behind the anterior nostril. This pore is immediately adjacent to the third SO pore, giving the appearance of a double pore. The adnasal pore is included in the count of the infraorbital canal, which is expressed as those along the upper jaw (including the adnasal) plus the one in line with these but behind the rictus plus those in the ascending branch of the canal behind the eye, for example 5+1+3. POM pores are given as those in the mandibular section plus those in the preopercular section. Pores in the other canals are given as total counts.

COI sequences were generated as per Weigt *et al.* (2012). Genbank accession numbers for these data are MF172254–MF172257.

Family Congridae

Genus *Conger* Bosc, 1817

Conger Bosc, 1817:450 (type species *Muraena conger* Linnaeus, 1758, by subsequent absolute tautonymy)

Definition (after Smith, 1989). Body moderately elongate, anus before midlength. Tail moderately slender, neither blunt-tipped nor attenuate, caudal fin flexible. DFO behind base of pectoral fin, from approximately over mid-pectoral fin to well behind its tip. Pectoral fin well developed.

Jaws nearly equal, fleshy part of snout extending slightly in front of intermaxillary tooth patch. Well-developed flange on upper and lower lips, that of upper lip wide. Head pores small, those along upper jaw located on side of head instead of on flange. Preoperculo-mandibular canal with 9–11 pores, usually 9 (except for *C. cinereus*, which usually has 10), seven or eight in mandibular section and two in preopercular section. Infraorbital canal contains a well-developed adnasal pore, immediately adjacent to third SO pore, the two forming what appears to be a double pore; four pores along upper jaw, one in line with these behind rictus, and 0–3 in ascending branch behind eye. Supraorbital canal with three pores, all near tip of snout, the third immediately adjacent to adnasal pore. Supratemporal canal with a single median pore in all species except the Atlantic *C. triporiceps*, which has three pores.

Teeth small, acute. Intermaxillary tooth patch rounded, not distinctly separated from maxillary and vomerine teeth. Vomerine tooth patch short, triangular. Maxillary and dentary teeth in one or two rows, the outer row forming a cutting edge, the inner row (when present) fewer, blunter and more widely spaced.

Digestive tract pale. Stomach rather long, not quite reaching anus posteriorly. Gas bladder reaching anus posteriorly.

Size variable, some species reaching up to 3 m TL, most smaller than 1 m.

Key to species of *Conger* in Taiwan

- 1a Two or 3 pores (rarely 0 or 1) behind eye; black diagonal streak usually present below eye; rictus under or slightly behind posterior margin of eye; 6th IO pore above and slightly behind rictus, by a distance of less than one pore diameter *C. cinereus*
- 1b No pores behind eye; no black streak below eye; rictus extending to below posterior half of eye; 6th IO pore about level with and well behind rictus, by a distance of several pore diameters 2
- 2a DFO clearly behind tip of pectoral fin; single row of teeth on upper jaw 3
- 2b DFO over or slightly behind pectoral fin; one additional row of teeth on inner side of upper jaw 4
- 3a Body mostly blackish or dark grayish, vertical fins with white bases and black margins; trunk length 1.4–1.9 times head length; total vertebrae 140–146. *C. jordani*
- 3b Body yellowish to grayish, never dark, vertical fins mostly pale to light grayish with clear white margin; trunk length 1.9–2.3 times head length; total vertebrae 131–133. *C. philippinus*
- 4a Head small, 12.3–14.9% TL; trunk length 1.5–2.1 times head length; white dots on dorsal surface. *C. myriaster*
- 4b Head large, 15.4–17.7% TL; trunk length 1.2–1.6 times head length; dorsal surface uniformly light gray, without white dots *C. macrocephalus*

Conger cinereus Rüppell, 1871

Figs. 1, 2A, 3A; Table 1

Conger cinereus Rüppell in Klunzinger, 1871:607 (Type locality: Red Sea. Holotype: SMF 766 [not an independent species description, but a new genus applied to *Conger* assigned to *Muraena cinerea* Forsskal, 1775, a muraenesocid]). First available usage as *Conger cinereus* Rüppell in Klunzinger, 1871 (Fricke, 2008:15). Chen & Weng, 1967:50; Chen, 1969:132; Shen, 1984:112; Chen & Yu, 1986:252; Shen *et al.*, 1993:116; Shao *et al.*, 2008:239; Ho *et al.*, 2015:146.

Specimens examined. 55 specimens, 53–945 mm TL. *ASIZP 54973 (1, 407), Hengchun, Pingtung, southern Taiwan, 28 Dec. 1977. *ASIZP 56623 (1, 468), Hengchun, Pingtung, 1 Oct. 1975. *ASIZP 56903 (1, 383), Hengchun, Pingtung, 25 May 1975. *ASIZP 57461 (1, 93), Lanyu, Taitung, southeastern Taiwan, 20 Sep. 1979. *ASIZP 57701 (2, 94–128), Mao-pi-tou, Pingtung, 1 Aug. 1969. *ASIZP 57962 (1, 283), Dongsha Atoll (Pratas Atoll), South China Sea, 7 May 1990. *ASIZP 58008 (1, 104), Longken, Pingtung, 25 Mar. 1988. *ASIZP 58985 (1, 165), Huawan, Pingtung, 14 Mar. 1990. *ASIZP 60201 (1, 95), Mao-pi-tou, Pingtung, 25 Apr. 1975. *ASIZP 63600 (1, 565), Daxi, Yilan, northeastern Taiwan, 29 Sep. 2000. ASIZP 69766 (1, ca. 600) and ASIZP 69770 (1, ca. 600), Changbin, Taitung, 6 May 2005. NMMB-P1358 (2, 182+–220), Wan-li-tong, Pingtung, 22 Apr. 1968. *NMMB-P1396 (1, 217), O-luan-bi, Pingtung, 15 Sep. 1966. NMMB-P1397 (1, 155), Wan-li-tong, Pingtung, 22 Apr. 1968. *NMMB-P1476 (1, 257+), Hsiao-liu-chiou, Pingtung, 16 Mar. 1966. *NMMB-P1477 (2, 199+–257), Wan-li-tong, Pingtung, 17 May 1966. NMMB-P3012 (1, 134), no data. NMMB-P3797 (1, 155), *NMMB-P4458 (5, 71–338+), Hsiao-liu-chiou, Pingtung, 20 Mar. 1973. NMMB-P24265 (1, 366+), Taiwan, no other data. NMMB-P27759 (1, 945), NMMB-P27760 (1, 800), Cheng-gong, Taitung, 22 Jun. 2017. USNM 311259 (1, 455), east side of east line of rocks on point just southwest of Yeh-liu, Taipei, northern Taiwan, 0–5 m, 18 May 1968. USNM 311260 (8, 83–253+), cut between large outstanding rock and Ch'uan-fan-shih, Pingtung, 0–6 m, 23 Apr. 1968. USNM 311266 (1, 106), rocky headland northwest of swimming beach of Sha-tao, 0–5 m, 5 May 1968. USNM 311269 (1, 238), southwest end of Taiwan, approximately 2 km southwest of Ta-fan-lieh, 0–2 m, 5 May 1968. USNM 311270 (1, 53), southeast tip of Taiwan, Pacific Ocean side, 0–2 m, 27 Apr 1968. USNM 311272 (1, 158), southwest end of Taiwan, tidal flat at Ta-fan-lieh, 1 m, 25 Apr. 1968. USNM 311273 (1, 83), southwest shore just off Ch'uan-fan-shih, 8–9 m, 3 May 1968. USNM 311274 (1, 88), southwest shore just off Ch'uan-fan-shih, 5–6 m, 28 Apr 1968. USNM 311277 (1, 423+), southwest end of Taiwan, approximately 2 km southwest of Ta-fan-lieh, 0–0.8 m, 26 Apr 1968. USNM 311284 (3, 106–386), rocky shore just south of Chin-chiao-wan, south end of Taiwan, 8 May 1968. USNM 311287 (8, 87–206), bay between K'en-ting and Ta-yuan Shan, 5–9 m, 1 May 1968.

Diagnosis. Pores present behind eye. Sixth IO pore above and less than one pore diameter behind rictus. Rictus under or slightly behind posterior margin of eye (Fig. 2A). DFO over middle of pectoral fin, predorsal length less than 15% TL, preanal length 30.7–33.8 % TL. Black streak below eye parallel to upper lip. Vertebrae 140–148 in Taiwan [139–146 from elsewhere].

Description. See Table 1 for morphometric data. Lateral-line pores: prepectoral usually 4–6 (1 with 8); predorsal 6–10; preanal 36–40; total 130–142. Head pores (Fig. 2A): SO 3, IO 5+1+2–3 (rarely 5+1+0–1; 5 on upper jaw + 1 behind rictus + 0–3 behind eye), POM 10 (rarely 9, 7 on lower jaw, 3 behind rictus), ST 1. Vertebrae: predorsal 9–11; preanal 36–39; total 140–148; MVF 10–38–143.

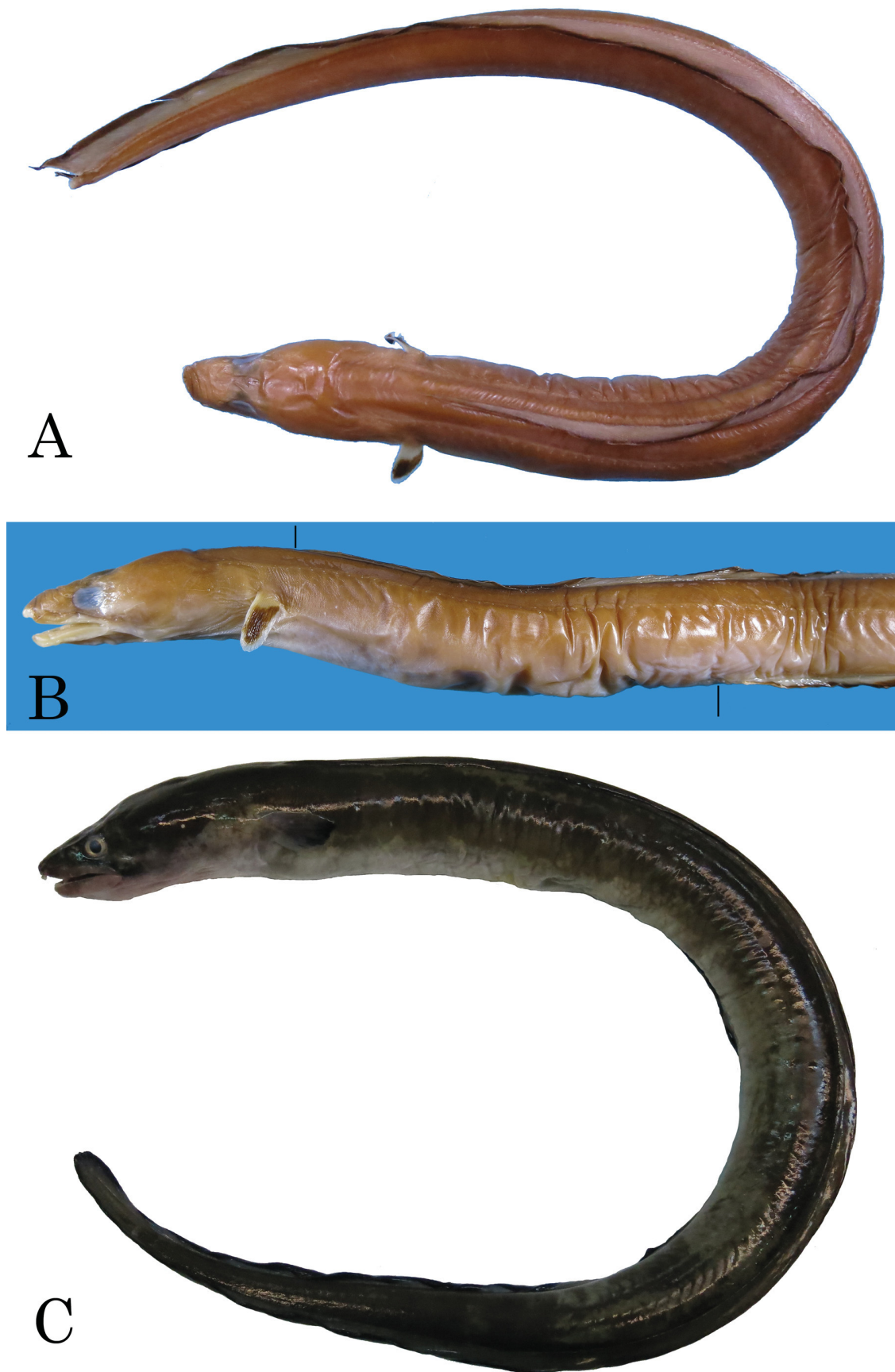


FIGURE 1. A–B. *Conger cinereus* Rüppell, 1871, NMMB-P4458, 338+ mm TL. Bars indicate origins of dorsal fin (above) and anal fin (below). C. NMMB-P27759, 945 mm TL.

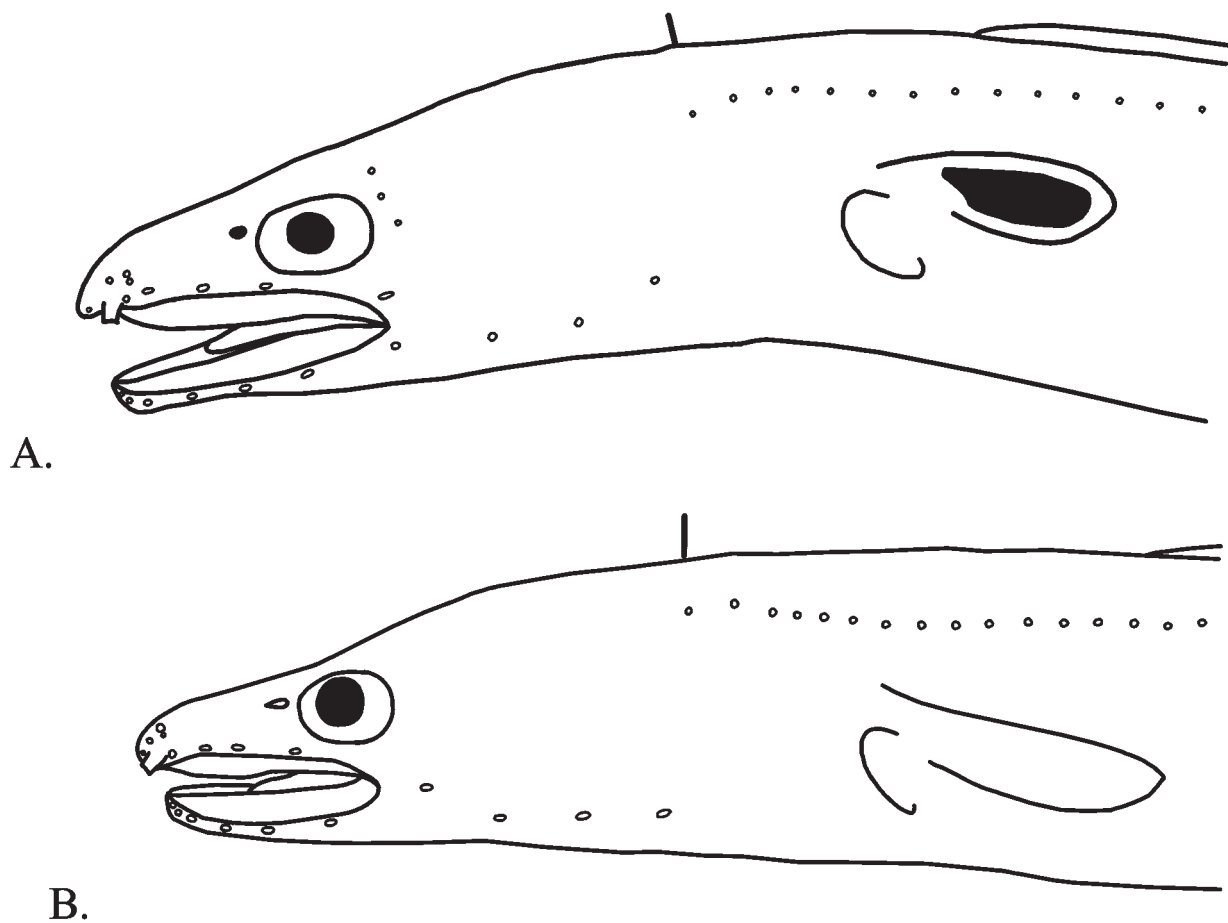


FIGURE 2. Line drawings demonstrating the arrangement of head pores of two species. **A.** *C. cinereus*. **B.** *C. myriaster*. Bar indicates the ST pore.

DFO over middle of pectoral fin. Angle of rictus under posterior margin of eye, 6th IO pore above and less than one pore diameter behind rictus. Maxillary teeth none to few in inner row of upper jaw and up to 15 in that of lower jaw (Fig. 3A). Color medium to dark brown; black margin on dorsal and anal fins; a dark streak below eye parallel to upper lip; dark spot often present on pectoral fin. In life, commonly shows a pattern of dark bars on body at night, but these usually do not remain in preservative.

Maximum size 1400 mm TL (Allen & Erdmann, 2012).

Distribution. Widespread in the Indo-west Pacific Ocean, from the coast of Africa and the Red Sea to the islands of the central Pacific. Commonly found in shallow waters near coral reef areas.

Remarks. *Conger cinereus* was described by Rüppell (1830) from the Red Sea. Although his text and figure clearly refer to the species we now know as *Conger cinereus*, he treated it as a new combination for what we now call *Muraenesox cinereus* (Forsskål), and not as a new species. The name dates from 1871, when Klunzinger gave an explicit description and credited the name to Rüppell.

This is the most distinctive species in several characters. The jaw is longer in relation to the eye than in the other species, with the rictus beneath the posterior margin of the eye. This also alters the position of the 6th IO pore, which is located above and immediately behind the rictus. In other species, the rictus is well before the posterior margin of the eye, and the 6th IO pore is well behind the rictus at about the same horizontal level. There are usually 10 POM pores, whereas the other species in Taiwan typically have 9. The DFO is more anterior, over the middle of the pectoral fin, with a correspondingly lesser predorsal length. The preanal length is also less than in the other species. The oblique stripe below the eye is unique to *C. cinereus*, as is the barred color pattern it sometimes shows. It is the species most commonly found in shallow water on coral reefs.

TABLE 1. Morphometric and meristic data of three *Conger* species in Taiwan. Mean values are provided followed by range in parentheses, except for lateral-line pores.

	<i>C. cinereus</i>	<i>C. jordani</i>	<i>C. macrocephalus</i>
Total length (TL) (mm)	217–565 (n = 12)	130–458 (n = 9)	286–861 (n = 28)
%TL			
Head length (HL)	12.0 (11.5–12.7)	13.8 (13.3–14.3)	16.6 (15.4–17.7)
Predorsal length	13.5 (12.8–14.1)	19.5 (18.8–20.6)	21.9 (20.8–23.5)
Preanal length (PAL)	32.6 (30.7–33.8)	36.6 (35.3–38.3)	39.3 (37.8–40.7)
Trunk length	20.3 (19.5–20.9)	22.7 (21.1–24.4)	22.8 (21.2–25.1)
Tail length	67.6 (66.8–68.9)	63.4 (61.7–64.7)	60.7 (59.3–62.2)
Depth at GO	3.7 (3.5–3.9)	4.6 (4.2–5.0)	6.1 (5.1–7.1)
Deep at anus	4.8 (3.8–6.1)	4.5 (4.2–5.2)	5.5 (4.4–6.6)
%PAL			
Head length	36.5 (35.4–38.7)	37.8 (35.5–40.4)	42.1 (38.0–44.8)
Predorsal length	41.3 (38.1–44.3)	53.4 (51.7–54.3)	55.8 (52.6–60.9)
Trunk length	63.4 (61.3–64.6)	62.2 (59.6–64.5)	57.9 (55.2–62.0)
%HL			
Snout	24.7 (22.4–26.4)	25.0 (24.2–26.1)	25.5 (23.6–28.4)
Eye diameter	14.6 (12.2–16.3)	16.4 (15.5–17.1)	16.3 (13.7–18.7)
Interorbital width	13.9 (11.1–16.0)	14.5 (12.4–15.6)	15.6 (12.2–17.5)
Upper-jaw length	37.4 (33.0–41.5)	34.5 (32.3–36.4)	34.0 (29.9–38.4)
Interbranchial width	28.7 (22.2–36.3)	25.4 (22.3–32.5)	27.4 (21.0–33.6)
Pectoral-fin length	28.1 (23.7–33.0)	31.5 (27.4–37.9)	30.1 (23.4–34.7)
Gill-opening length	12.7 (9.8–14.7)	13.3 (10.8–15.5)	11.4 (8.0–13.1)
Trunk length/HL	1.6–1.8	1.4–1.9	1.2–1.6
Vertebrae	n = 7	n = 15	n = 23
Predorsal	9.7 (9–11)	15.3 (14–16)	14.4 (12–16)
Preanal	38.4 (37–39)	38.6 (37–39)	36.9 (34–39)
Total	143.3 (140–148)	143.3 (140–146)	135.8 (132–139)
Lateral-line pores	n = 25	n = 15	n = 23
Prepectoral	4–6	4–6	5–6
Predorsal	6–10	13–15	12–15
Preanal length	36–40	35–38	32–38
Total	130–142	135–138	121–133

Kanazawa (1958) reported two rows of maxillary teeth in this species, but we found only one row with a few additional teeth around the anterior portion of the upper jaw, whereas up to 15 in that of the lower jaw.

Kanazawa (1958) divided this species into two subspecies, *Conger cinereus marginatus* Valenciennes in Eydoux & Souleyet from Hawaii and *Conger cinereus cinereus* from elsewhere. Recent genetic data suggest that there may be additional subdivisions within *C. c. cinereus* (Smith, unpub. data). Further studies are needed to determine the taxonomic structure of *Conger cinereus*.

***Conger jordani* Kanazawa, 1958**

Figs. 3B, 4; Table 1

Conger jordani Kanazawa, 1958:250, fig. 4; pl. 1, fig. G (Type locality: Misaki, Japan, Albatross. Holotype: USNM 71844).
Ho *et al.*, 2015:146.

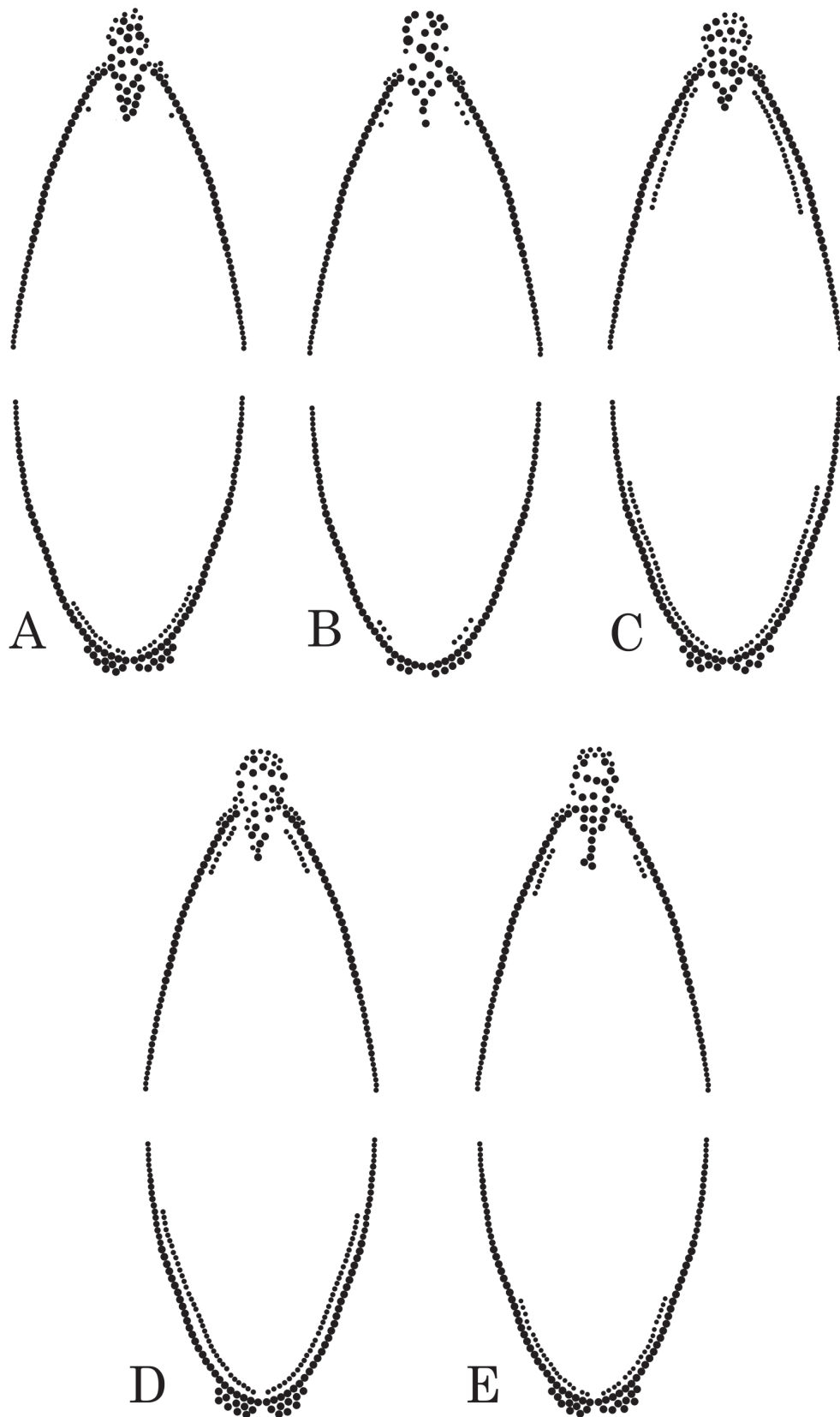


FIGURE 3. Demonstration of jaw tooth pattern of five *Conger* species in Taiwan. **A.** *C. cinereus*, from NMMB-P24265. **B.** *C. jordani*, from NMMB-P24766. **C.** *C. macrocephalus*, NMMB-P15401. **D.** *C. myriaster*, NMMB-P6392. **E.** *C. philippinus*, NMMB-P22425. Note that the numbers of principal teeth are not counted from the specimens.

Conger japonicus (not of Bleeker, 1879): ?Chen & Weng, 1967:49; ?Chen, 1969: 132; ?Shen, 1984:112; ?Shen, 1988:15; ?Shen *et al.*, 1993:116; ?Chen, 2004:32; ?Ho *et al.*, 2010:table 1.
Conger wilsoni (not of Bloch & Schneider, 1801): ?Chen & Yu, 1986:252.
Conger conger (not of Linnaeus, 1758): ?Lee & Yang, 1966:56, fig. 5.

Specimens examined. 32 specimens, 80–636 mm TL. **Taiwan:** *ASIZP 62593 (1, 401), Da-xi, Yilan, NE Taiwan, 11 Jul. 2003. *NMMB-P2540 (2, 389–438), Wan-li-tong, Pingtung, 15 Dec. 1978. *NMMB-P24766 (1, 428), Ke-tzu-liao, Kaohsiung, 15 Oct. 2016. *USNM 311373 (3, 80–382), Rocky point on northwest shore of first large cove on west side of island north of southern tip of island, 2 May 1968. *USNM 311374 (3, 92.5–135), Chuan-fan-shih, Pingtung, SW Taiwan, 23 Apr. 1968. *USNM 311375 (1, 130), Ken-ting, Pingtung, SW Taiwan, 22 Apr. 1968. *USNM 398804 (1, 350), Taiwan, 19 Oct. 2006. *USNM 398805 (1, 357), Taiwan, 19 Oct. 2006. *USNM 398806 (1, 418), Taiwan, 12 Feb 2007. *USNM 398807 (3, 80–458), Taiwan. **Japan:** USNM 26250 (1, 596, paratype), Japan. USNM 49866 (1, 382, paratype), Misaki. USNM 71715 (1, 491, paratype), Misaki, 1906. USNM 71716 (1, 452, paratype), Misaki, 1906. USNM 71819 (1, 636, paratype), Okinawa. USNM 71843 (1, 480, paratype), Misaki, 1906. USNM 71844 (1, 605, holotype), Misaki, 1906. USNM 71845 (1, 579, paratype), Misaki, 1906. USNM 71915 (1, 533), Misaki, 1906. USNM 71963 (1, 565, paratype), Misaki, 1906. USNM 72003 (1, 633, paratype), Misaki, 1906. USNM 163467 (1, 506, paratype), Kagoshima, 19 Aug 1906. USNM 179791 (1, 167), Gogashima near Misaki, 27 Apr 1929. **South Africa (tentative identification):** USNM 171997 (1, 406), Port Alfred. USNM 171998 (1, 630), Great Fish Point.

Diagnosis. DFO behind pectoral fin. Maxillary teeth mainly in one row, except for 1–4 extra teeth on inner row (Fig. 3B). Vertebrae 140–146.



FIGURE 4. *Conger jordani* Kanazawa, 1958. **A–B.** NMMB-P24766, 428 mm TL. Bars indicate origins of dorsal fin (above) and anal fin (below).

Description. See Table 1 for morphometric data. Lateral-line pores: prepectoral 4–6; predorsal 13–15; preanal 35–38; total 135–138. Head pores: SO 4, IO 5 (4 on upper jaw + 1 behind rictus), POM 9 (6 on lower jaw, 3 behind rictus), ST 1. Vertebrae: predorsal 14–16; preanal 37–39; total 140–146; MVF 15–39–143.

DFO well behind pectoral fin. Angle of jaw before posterior margin of eye, 6th IO pore at level of and more than one pore diameter behind rictus. Usually none to as many as 4 small teeth present in inner row of teeth on each jaw (Fig. 3B).

When preserved, most dorsal and lateral surfaces uniformly black, ventral surface slightly paler; pectoral fin blackish; throat and upper lip pale; median fins white with black base and margins, posterior portion entirely black.

Maximum size 636 mm TL, expected to be larger than this.

Distribution. Known from Japan and Taiwan, and possibly South Africa.

Remarks. In Taiwan, both this species and *Conger macrocephalus* (see below) have been confused under the name *Conger japonicus* (see Smith, *et al.*, 2016 for a clarification of the latter name). *Conger jordani* is distinguished by its posterior DFO and the presence of a single row of maxillary teeth, except for 1–4 small teeth on the inner row that may be present anteriorly in some specimens. Kanazawa (1958) tentatively recorded this species from South Africa on the basis of two specimens, but noted that the DFO was more anterior than in the Japanese specimens. Although he did not give catalog numbers for the South African specimens, they are apparently USNM 171997 and 171998. Further studies with additional material are needed to assess the taxonomic status of the South Africa population.

***Conger macrocephalus* Kanazawa, 1958**

Figs. 3C, 5; Table 1

Conger macrocephalus Kanazawa, 1958:254, pl. 1, fig. M (type locality: Verde Island passage, Luzon Island, Philippines, 13°34'37"N, 121°07'30"E, Albatross station 5367, depth about 180 fathoms. Holotype: USNM 164334). Ho *et al.*, 2015:146.

Conger japonicus (not of Bleeker, 1879, part). ?Chen & Weng, 1967:49; ?Chen, 1969: 132; ?Shen, 1984:112; ?Shen, 1988:15; ?Shen *et al.*, 1993:116; ?Chen, 2004:32; ?Ho *et al.*, 2010:table 1.

Conger wilsoni (not of Bloch & Schneider, 1801): ?Chen & Yu, 1986:252.

Conger conger (not of Linnaeus, 1758): ?Lee & Yang, 1966:56, fig. 5.

Specimens examined. 42 specimens, 286–822 mm TL. **Taiwan:** *NMMB-P3365 (1, 415), Taiwan, no further data. *NMMB-P4531 (1, 551), Hsiao-liu-chiou, Pingtung, 10 Mar. 1966. *NMMB-P6117 (4, 286–351), Daxi, Yilan, 8 May 2003. *NMMB-P11166 (2, 365–462), Dong-gang, 15 Dec. 2009. *NMMB-P11178 (1, 294), Dong-gang, 13 Sep. 2010. *NMMB-P11183 (1, 475), Dong-gang, 15 Dec. 2010. *NMMB-P11907 (1, 491), Dong-gang, 26 Feb. 2011. *NMMB-P11922 (1, 315), Dong-gang, 28 Jan. 2011. *NMMB-P13157 (1, 466), Dong-gang, 12 Sep. 2009. *NMMB-P13866 (2, 470–479), Dong-gang, 10 Aug. 2011. *NMMB-P14069 (2, 432–663), Changbin, Taitung, 15 Sp. 2011. *NMMB-P15401 (1, 391), Changbin, Taitung, 30 Sep. 2011. *NMMB-P16550 (3, 412–502), Changbin, Taitung, 15 Feb. 2012. NMMB-P23926 (2, 408–424), Dong-gang, 17 Feb. 2016. NMMB-P24026 (1, 326), Dong-gang, 13 Mar. 2015. NMMB-P24860 (1, 363), Ke-tzu-liao, Kaohsiung, 2 Apr. 2015. *USNM 398727 (1, 333), Dong-gang, 10 Nov. 2009. *USNM 398808 (1, 443), Taiwan, 7 Feb. 2007. *USNM 398809 (1, 434), Taiwan, no date. *USNM 401056 (1, 562), Dong-gang, 8 Nov. 2009. *USNM 401077 (4, 393–506), Dong-gang, 14 Nov. 2009. *USNM 404406 (1, 816), Dong-gang, 8 Nov. 2009. USNM 437347 (1, 373), Dong-gang, 22 May 2014. *USNM 437348 (2, 350–425), Dong-gang, 6 Nov. 2015. Tentative identification. NMMB-P282 (dried out).

Other localities: **Philippines:** USNM 164334 (1, 796, holotype), Verde Island Passage, 13°34' 37"N, 121°07'30"E, 180 fathoms (329 m), 22 Feb 1909. USNM 438040 (1, 558), Negros Oriental, Dumaguete, 10 Jul 2015. USNM 438049 (1, 434), Negros Oriental, Dumaguete, 5 Feb 2013. **Oman:** USNM 410631 (1, 495), 16°23'19.11"N, 54°34'52.02"E, 2007. **Samoa:** ANSP 146127 (1, 822), no other data.

Diagnosis. Head very long, 15.4–17.7% TL, 38.0–44.8% PAL. DFO over posterior half to tip of pectoral fin. Inner row of dentary teeth longer than half of outer row (Fig. 3C). Vertebrae 132–139.

Description. See Table 1 for morphometric data. Lateral-line pores: prepectoral 5–6; predorsal 12–15; preanal 32–38; total 121–133. Head pores: SO 4, IO 6 (5 on upper jaw + 1 behind rictus), POM 9 (rarely 10, 6 on lower jaw, 3 behind rictus), ST 1. Vertebrae: predorsal 13–16; preanal 34–39; total 132–139; MVF 14–37–136.

DFO over posterior part of pectoral fin. Angle of jaw before posterior margin of eye, 6th IO pore at level of

and more than one pore diameter behind rictus. Two rows of teeth on each jaw; inner row of maxillary teeth about half length of outer row, inner row of dentary teeth longer than half length of outer length. When fresh, uniformly brown with black margins on median fins; pectoral fin pale or with a large black patch. When preserved, uniformly pale grayish to brownish, ventral surface slightly paler; pectoral fin grayish; median fins white with black margins, the black margins on posterior portion broader.

Maximum size at least 822 mm TL based on our examination.

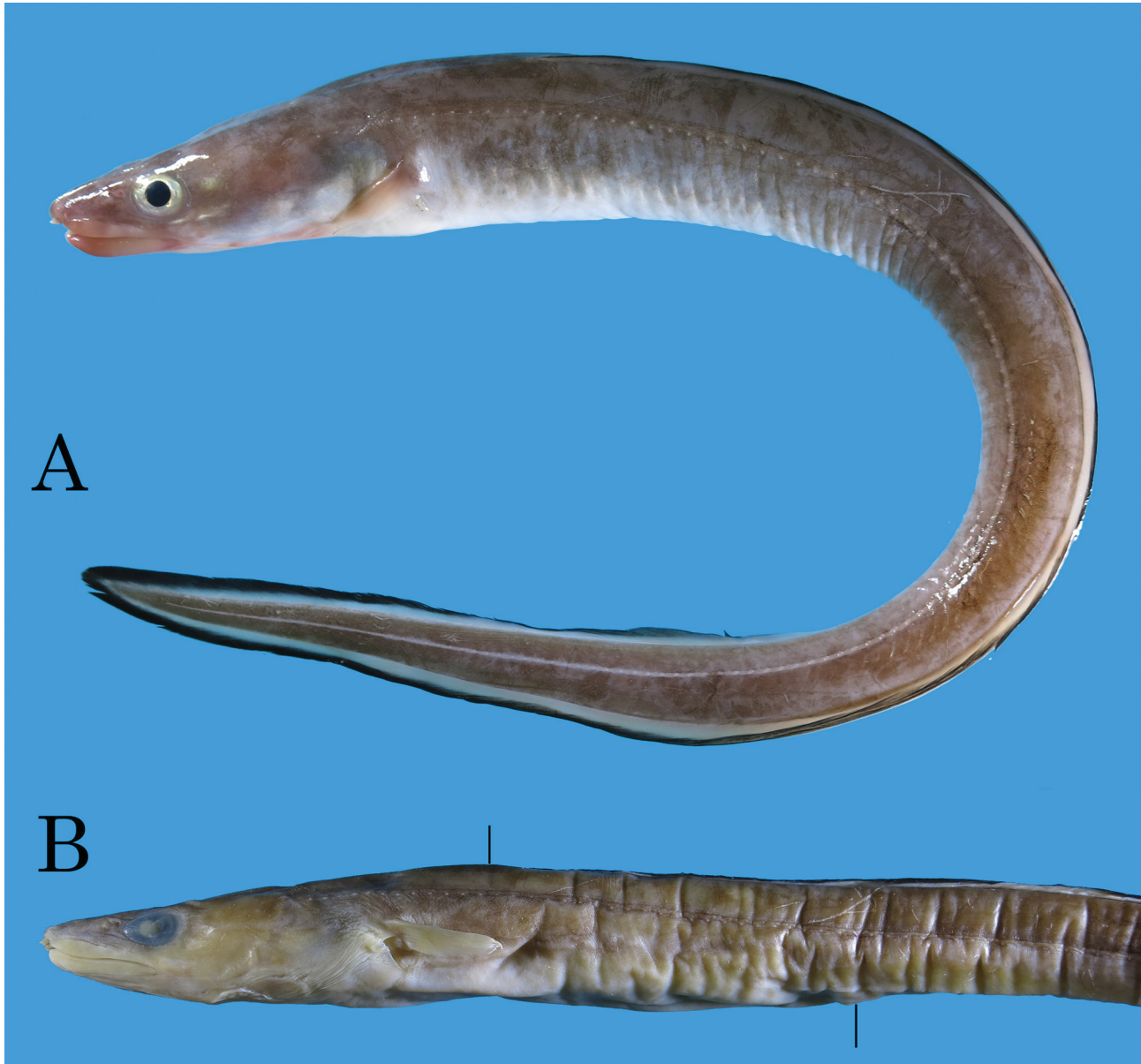


FIGURE 5. *Conger macrocephalus* Kanazawa, 1958. **A–B.** NMMB-P24026, 326 mm TL. Bars indicate origins of dorsal fin (above) and anal fin (below).

Distribution. Kanazawa (1958) described this species based on a single specimen collected from the Philippines. Ho *et al.* (2015) first reported it from Taiwan, where it was previously misidentified as *Conger japonicus*. Smith *et al.* (2017) reported a specimen from Oman in the northwestern Indian Ocean and suggested that the specimen recorded from Réunion by Quéro & Saldanha (1995) as *Conger wilsoni* might be *C. macrocephalus* instead, based on its relatively long head (17% TL) and low vertebral count (138). In addition, we have examined a specimen from Samoa that also appears to be *C. macrocephalus* (head length 17% TL, vertebrae 138). The species thus seems to occur over a wide area of the tropical Indo-Pacific.

Remarks. *Conger macrocephalus* is the most common species found in Taiwan. It is characterized by an especially large head, head length 15.4–17.7% TL compared to 11.5–14.9% TL in the other species in Taiwan.

Although Kanazawa (1958) described the DFO over the pectoral fin, we found our specimens with the location of the DFO ranging from the middle of the pectoral fin to slightly behind the tip of the fin.

Genetic data are available for USNM 398727, 401056, and 404406 under Genbank accession numbers MF172254–MF172256.

***Conger myriaster* (Brevoort, 1856)**

Figs. 2B, 3D, 6; Table 2

Anguilla myriaster Brevoort, 1856:282, pl. 11, fig. 2 (Type locality: Hakodate, Hokkaido, Japan. No types known).

Conger myriaster: Lee & Yang, 1966:56, fig. 4; Chen & Weng, 1967:48; Chen, 1969: 132; Shen, 1984:112; Chen & Yu, 1986:252; Shen *et al.*, 1993:116; Shao *et al.*, 2008:239; Ho *et al.*, 2010:table 1.

Conger japonicus Bleeker, 1879:32, Pl. 2, fig. 2 (Type locality: Japan. Holotype: ZMH 3748).

Specimens examined. 21 specimens, 154–840 mm TL. **Taiwan:** *NMMB-P4983 (1, 545), Penghu, Taiwan Strait, 1 Aug. 1957. *NMMB-P6392 (1, 423), Daxi, Yilan, 23 Jan. 1994. *NMMB-P11172 (1, 473), Dong-gang, 15 Dec. 2009. *NMMB-P12216 (1, 554+), Daxi, Yilan, 22 Jan. 2010. NMMB-P27758 (1, 840), Daxi, Yilan, 1 Jul. 2017. USNM 439338 (1, 515+), mature male, Daxi, Yilan, 29 Jun. 2007. **Other localities: Japan:** *USNM 49977 (6, 154–440), Tokyo Prefecture, Honshu Island. *USNM 75981 (1, 509), off Honshu Island, 379–457 m, 12 May 1900. *USNM 151740 (1, 563), Fukui, Japan, Oct.–Nov. 1922. *USNM 151793 (1, 227), Honshu, Japan, Oct.–Nov. 1922. ZMH 3748 (1, 329, holotype). **China:** *USNM 130468 (3, 315–367), Tsingtao, Shandong, Aug. 1926. *USNM 328953 (1, 304) and *USNM 329102 (1, 301), Shandong, 26 Jul. 1993.

Diagnosis. DFO over posterior half of pectoral fin. Inner row of teeth in lower jaw more than half the length of outer row (Fig. 3D). Vertebrae 142–148. A row of white spots on body above lateral line, lateral-line pores and sensory papillae on head white.

Description. See Table 1 for morphometric data. Lateral-line pores: prepectoral 5–6; predorsal 12–13; preanal 38–42; total 134–141. Head pores (Fig. 2B): SO 4, IO 6 (5 on upper jaw + 1 behind rictus), POM 9 or 10 (6 or 7 on lower jaw, 3 behind rictus), ST 1. Vertebrae: predorsal 13–16; preanal 39–44; total 142–148; MVF 14–42–145.

DFO over posterior part of pectoral fin. Angle of jaw before posterior margin of eye, 6th IO pore at level of and more than one pore diameter behind rictus (Fig. 2B). Two rows of teeth on each jaw; inner row of maxillary teeth short, inner row of dentary teeth about 1/2 to subequal of length of outer row (Fig. 3D). When preserved, dorsal surface light grayish, ventral surface paler; a row of white spots on side of body above lateral line, lateral-line pores and sensory papillae on head white.

Maximum size 1000 mm TL (Masuda *et al.*, 1984).

Distribution. Known from Japan, Taiwan and China.

Remarks. NMMB-P12216 has only a few teeth on the inner row of the upper jaw and a somewhat shorter inner row, about 1/2 the length of the outer row on the lower jaw. Kanazawa (1958) also mentioned some of his specimens have only a few teeth in the inner row, thus it is treated as individual variation.

NMMB-P4983 has a few teeth on the inner row of the upper jaw and a somewhat shorter inner row (about 1/2 of outer row) of teeth on the lower jaw. The DFO is well behind the pectoral fin. The head pores are similar to the others. The tooth pattern is identical to NMMB-P12216. However, the color of NMMB-P4983 is somewhat faded, so it might be a *C. myriaster* with a posterior DFO.

Life history and reproduction. *Conger myriaster* is the most common species of *Conger* in Japan and is an important commercial species. At least some species of *Conger*, like those of *Anguilla*, undertake long spawning migrations to areas of deep water far from shore. Also, like *Anguilla*, species that live in temperate waters appear to travel greater distances than those of the tropics. Very young larvae of ca. 5–6 mm in length have recently been collected in the western North Pacific along the Kyushu-Palau Ridge (Miller *et al.*, 2011; Kurogi *et al.*, 2012), slightly to the north and west of the spawning ground of *Anguilla japonica*. From there, the larvae are carried back to the coast by the prevailing currents. The larvae were identified genetically by matching the sequences of the mitochondrial 16s rRNA and cytochrome oxidase I with the comparable genes in adult *Conger myriaster*.

Although spawning areas have been located by finding the newly hatched larvae, adults have still not been collected in the open ocean. The adults leave the coast before becoming fully mature and apparently never return. They mature, spawn, and die in the open ocean. Cunningham (1891–92) described his observations on maturing *Conger conger* in an aquarium in Plymouth, England. He reported finding a “perfectly ripe male” and described its appearance:



FIGURE 6. *Conger myriaster* (Brevoort, 1856). **A.** NMMB-P27758, 840 mm TL. **B.** NMMB-P11172, 473 mm TL. **C.** USNM 439338, mature male, 515+ mm TL.

“It was quite a small specimen and somewhat thin; the peculiarities about it were its large prominent eyes and short broad snout. The eyes were so large in proportion to the head that their upper edges project[ed] slightly above the dorsal surface of the skull, and that surface between the eyes was quite depressed and hollow.”

He later reported that both ripe males and females had lost most of their teeth and the bones of the head had become soft and flexible. He also noted that they stopped feeding. Unfortunately, he did not illustrate either the males or the females. As such specimens are not found naturally in coastal waters, it seems likely that they mature only after they have reached the spawning area.

We report here the collection of a specimen (USNM 439338, 515+ mm TL), from a market in northeastern Taiwan that appears to be a mature male (Fig. 6C). It is very different in appearance from all the other specimens: uniformly black with a relatively large head and narrow body, a long pectoral fin, and a large eye. The gut is empty, and well-developed testes are present. The snout has a rather deep, squared-off appearance, and the flange on the upper lip is greatly reduced. Indeed, it would have been difficult to recognize as a *Conger* had its identity not been confirmed through DNA analysis. The CO1 sequence (Genbank accession MF172257) was blasted against the BOLD database to find the closest match. The result, based on 19 specimens, was a 99.84–100 percent match with *Conger myriaster*.

Morphological characters confirm the identification. The dentition is typical of *Conger*, as is the number and arrangement of pores and the position of the dorsal-fin origin over the end of the pectoral fin. Most notable is the presence of an adnasal pore in close proximity to the third SO pore, giving the appearance of a double pore, a diagnostic feature in *Conger*. There are no morphological characters that would falsify this identification. The specimen is missing part of the tail, and the body is badly abraded. The bones are soft and pliable, and the teeth are small and weak. The tip of the tail is missing, and 138 vertebrae are present. The specimen is 515 mm in length. The proportions are nearly normal, however, and the number of vertebrae is only slightly lower than normal, indicating that only a small portion of the tail has been lost. The specimen was collected from a market in northeastern Taiwan, but the exact location of capture is not known.

***Conger philippinus* Kanazawa, 1958**

Figs. 3E, 7; Table 2

Conger philippinus Kanazawa, 1958:255, pl. 1, fig. K (Type locality: Market in Cebu, Philippines. Holotype: USNM 134969).

Specimens examined. 8 specimens, 232–421 mm TL. **Taiwan.** *NMMB-P22425 (1, 347), Ke-tzu-liao, Kaohsiung, 11 Feb. 2015. *NMMB-P23575 (1, 421), Dong-gang, Pingtung, 9 Aug. 2016. **Philippines.** USNM 134969 (1, 232, holotype), Cebu market, 22 Mar 1909. **Vietnam.** *NMMB-P12317 (1, 378), Hanoi, 9 Apr. 2011. *NMMB-P17943 (2, 305–403), Phan Thiet, 29 May 2012. USNM 399971 (2, 262–277), Mui, 28 Jan 2010.

Diagnosis. DFO well behind tip of pectoral fin. Usually two rows of teeth on each jaw; 0–8 in inner row of maxillary, ca. 20 in inner row of dentary. Vertebrae 131–133 (127–135 from outside Taiwan). Vertical fins white anteriorly and grayish posterior with clear white margins.

Description. See Table 1 for morphometric data. Lateral-line pores: prepectoral 4–5; predorsal 15–17; preanal 36–37; total 127–127. Head pores: SO 4, IO 6 (5 on upper jaw + 1 behind rictus), POM 9 (6 on lower jaw, 3 behind rictus), ST 1. Vertebrae: predorsal 16–17; preanal 36–37; total 131–133; MVF 17–37–132.

DFO well behind pectoral fin. Angle of jaw before posterior margin of eye, 6th IO pore at level of and more than one pore diameter behind rictus. Usually two rows of teeth on each jaw; upper jaw with 0–8 teeth on inner row; lower jaw with ca. 20 small teeth on inner row extending to anterior third of length of outer row (Fig. 3E).

When preserved, most dorsal and lateral surfaces uniformly pale in small specimens, lightly grayish in large specimens, ventral surface slightly paler; pectoral fin pale in small specimens, grayish on upper portion and pale on lower portion in large specimens; throat and upper lip pale; median fins mostly white, posterior portion blackish with white margin, caudal fin blackish with white margins.

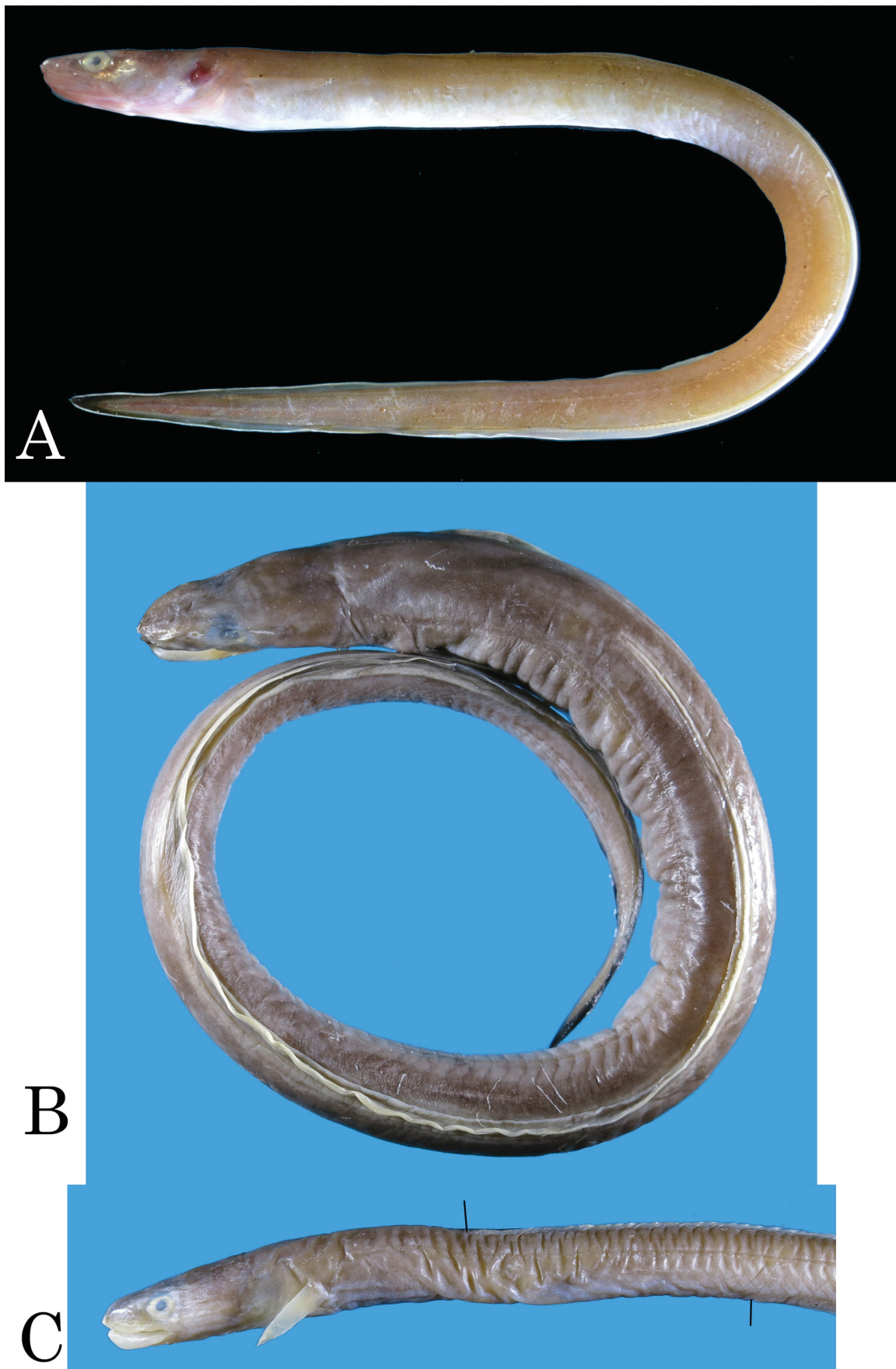


FIGURE 7. *Conger philippinus* Kanazawa, 1958. **A, C.** NMMB-P22425, 347 mm TL. **B.** NMMB-P23575, 421 mm TL. Bars indicate the origin of dorsal fin (above) and origin of anal fin (below).

TABLE 2. Morphometric and meristic data of two *Conger* species in Taiwan. Data of three specimens of *C. philippinus* from Vietnam are provided as well. Mean values are provided followed by range in parentheses, except for lateral-line pores.

	<i>*C. myriaster</i>	<i>C. philippinus</i>	
		Taiwan	Vietnam
Total length (TL) (mm)	227–563 (n = 15)	347–421 (n = 2)	305–403 (n = 3)
%TL			
Head length (HL)	13.7 (12.3–14.9)	12.0–12.4	11.1–12.4
Predorsal length	18.4 (17.7–18.9)	19.9–20.3	19.6–19.9
Preanal length (PAL)	38.1 (36.3–39.7)	37.1–37.8	36.0–36.7
Trunk length	24.5 (22.6–26.0)	25.0–25.3	24.3–24.8
Tail length	61.9 (60.3–63.7)	62.2–62.9	63.3–64.0
Depth at GO	5.2 (4.5–6.4)	4.0–4.3	3.9–4.4
Deep at anus	5.0 (4.0–5.9)	3.7–4.9	3.0–4.4
%PAL			
Head length	35.9 (32.1–38.2)	32.5–33.0	31.0–33.8
Predorsal length	48.5 (46.3–51.1)	53.7–53.8	54.2–54.6
Trunk length	64.1 (61.8–67.9)	67.0–67.5	66.2–69.0
%HL			
Snout	24.1 (21.5–26.3)	23.6–25.2	23.4–24.4
Eye diameter	13.4 (11.5–14.8)	15.0–17.6	17.2–17.7
Interorbital width	18.9 (14.6–21.1)	16.9–18.7	15.8–18.6
Upper-jaw length	31.3 (27.2–38.1)	34.3–36.7	34.0–35.4
Interbranchial width	26.6 (20.7–30.4)	19.9–28.4	20.6–28.1
Pectoral-fin length	39.0 (35.9–43.1)	35.9–46.5	36.9–43.0
Gill-opening length	15.8 (13.8–16.9)	11.0–14.1	12.0–14.3
Trunk length/HL	1.6–2.1	2.0–2.1	2.0–2.2
Vertebrae	n = 15	n = 2	n = 3
Predorsal	14.5 (13–16)	16–17	16–17
Preanal	41.6 (39–44)	37	36–37
Total	144.6 (142–148)	131–133	129–135
Lateral-line pores	n = 15	n = 2	n = 3
Prepectoral	5–6	4–5	4–5
Predorsal	12–13	15–17	16
Preanal length	38–42	36–37	36–37
Total	134–141	125–127	126–131

*Data of specimens collecting from Taiwan, China and Japan.

Maximum size at least 421 mm TL.

Distribution. Known from the Philippines, Taiwan, and Vietnam. Kanazawa (1958) tentatively referred literature references from the East Indies and Fiji to this species, but those records need to be confirmed.

Remarks. This is a relatively small species; the largest specimen examined was 421 mm TL. It can be distinguished by its posterior DFO and by having a white margin through the entire length of the vertical fins and relatively few total vertebrae, 131–133 (127–135 from outside Taiwan). It is common in bycatch of trawls in Vietnam based on HH's observation. Few differences are found between Taiwanese and Vietnamese specimens. The preanal length and trunk length are slightly longer and the tail length is slightly shorter in two Taiwanese specimens compared to three Vietnamese specimens examined (Table 2). The fresh color is quite yellow in

Vietnamese specimens, whereas Taiwanese specimens are relatively grayish. These differences are treated as individual variation temporarily. More specimens are needed for further study.

Discussion

Recently, Smith *et al.* (2016) discussed the status of *Conger japonicus* and concluded that it is a junior synonym of *C. myriaster*. They also discussed the diagnostic characters that separate the four species in Japan, including the presence or absence of an inner row of teeth on jaws, DFO over or behind the pectoral fin, number of pectoral-fin rays, head length, and presence or absence of postorbital pores. Here we discuss these four and some additional characters for the five species in Taiwan.

Jaw teeth. The outer row of teeth form a cutting edge on both jaws in all members of *Conger*. However, the number of teeth in the inner row of each jaw is highly variable among the congeners in Taiwan. *Conger jordani* usually has fewer than four small teeth in the inner row of each jaw (Fig. 3B). Others have zero to one additional short to moderately long row of conical teeth at the inner side of the jaws.

In *C. macrocephalus* and *C. myriaster*, the length of the inner row in the upper jaw runs about 1/3 to 1/2 of the length of the outer row, and in the lower jaw about 2/3 to subequal to the outer row (Figs. 3C, D, respectively). The tooth pattern in *C. philippinus* (Fig. 3E) is similar to that of *C. myriaster* (Fig. 3D), but with fewer teeth on the inner row of the upper jaw.

On the other hand, we found our specimens of *C. cinereus* have none or only a few additional teeth in the inner row at the anterior portion of the upper jaw and the inner tooth row is about one-third the length of the outer row on the lower jaw.

As mentioned by Kanazawa (1958), some individuals may have none or only a few teeth on the inner row, which should be considered when identifying a specimen.

Head pores. All five species have 3 SO pores; IO with 4 or 5 pores along upper jaw and 1 behind rictus. There are usually 9 POM pores (6 along the lower jaw and 3 behind rictus) in *C. jordani*, *C. macrocephalus*, *C. philippinus* and part of *C. myriaster*, whereas *C. cinereus*, part of *C. myriaster* and rarely in *C. macrocephalus* have 10 (7 along the lower jaw and 3 behind the rictus), 2 of which are POP pores. There are usually 2 or 3 (rarely 0 or 1) small pores (IO) behind the eye in *C. cinereus*, whereas the other four species have none.

Head size. The head is very large in *C. macrocephalus* (15.4–17.7% TL), relatively small in *C. cinereus* (11.5–12.7% TL) and *C. philippinus* (12.0–12.4% TL), and intermediate in the others (12.3–14.9% TL in *C. myriaster* and 13.3–14.3% TL in *C. jordani*). The body depth at gill opening is also largest in *C. macrocephalus* (5.1–7.1% TL), smallest in *C. cinereus* (3.5–3.9% TL), and intermediate in the other three species.

Dorsal-fin origin. The dorsal-fin origin is usually above the anterior half of the pectoral fin in *C. cinereus*, well behind the fin in *C. jordani* and *C. philippinus*, and usually above the posterior half of the pectoral fin in the other two species. However, predorsal length is greatest in *C. macrocephalus* (20.8–23.5% TL), shortest in *C. cinereus* (12.8–14.1% TL). It is notable that some individuals of *C. myriaster* and *C. macrocephalus* may have DFO slightly posterior to the tip of the pectoral fin.

Body proportions. In percentage of TL, preanal length is clearly short in *C. cinereus* (30.7–33.8 %TL) and relatively long in the others (35.3–40.7% TL). The trunk is shorter in *C. cinereus* (19.5–20.9%TL), whereas that of the other four species is relatively long, about 21.1–26.0% TL.

However, compared to the PAL, the trunk is relatively short in *C. macrocephalus* (mean 57.9% PAL), reflecting the greater head length in that species.

It is notable that the ratio of trunk length to head length shows significant differences between species; the trunk length is 2.0–2.2 times head length (reflected by its long PAL and small head) in *C. philippinus*, 1.5–1.9 times in *C. cinereus*, *C. jordani* and *C. myriaster*, whereas 1.3–1.5 times in *C. macrocephalus*.

Although the values are mostly overlapping, the size of the eye can be roughly divided into 2 groups. In *C. cinereus*, *C. myriaster* and *C. philippinus*, it is about 11 to 16% HL, whereas in *C. macrocephalus* and *C. jordani* it is about 13–18% HL. Interorbital space is relatively wide in *C. myriaster* (mean 18.9% HL), whereas the other four species have a mean value about 14–17% HL.

The pectoral fin is longer in *C. myriaster* (35.9–43.1 % HL) and *C. philippinus* (35.9–46.5% HL), than in the other three species (23.4–37.9% HL).

Distribution. Biogeographically, the presence of *Conger* species in Taiwan reflect its intermediate location. Two of the species, *C. jordani* and *C. myriaster*, represent southern extensions of species found elsewhere mainly in Japan. Two other species, *C. macrocephalus* and *C. philippinus*, were described from the Philippines and thus represent a northern extension of a southern species; they are not known from Japan. *Conger cinereus* is a widely distributed species found throughout the Indo-west Pacific. *Conger cinereus* is predominantly a shallow-water species commonly found on coral reefs. The other species occur in deeper water and are taken in trawls.

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